

Yellowstone Science

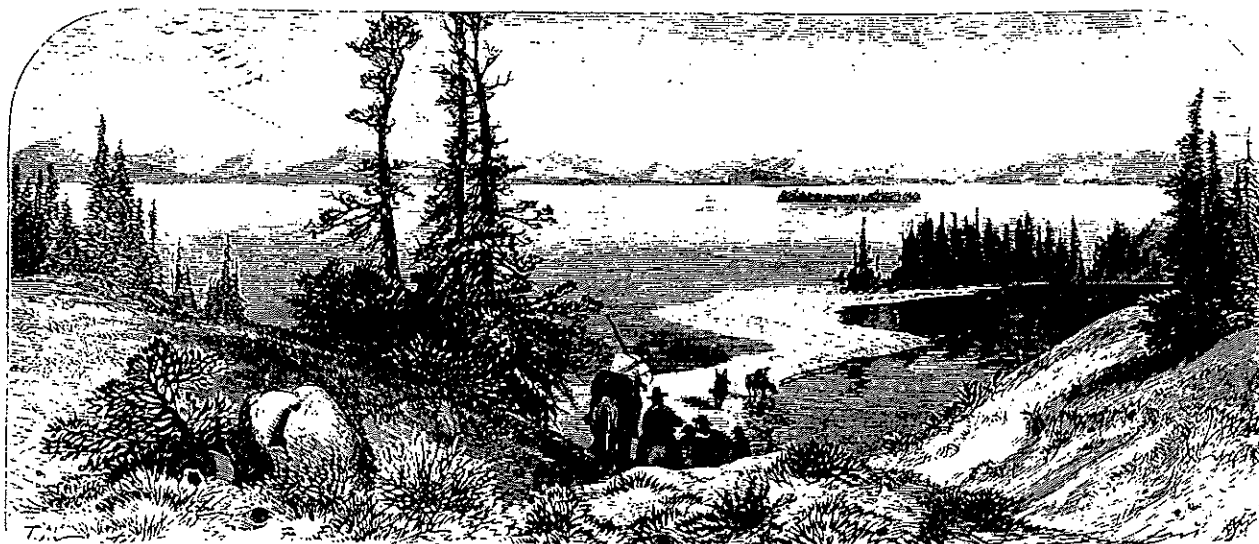
A quarterly publication devoted to the natural and cultural sciences



Yellowstone Climate Change
Packrats & Paleontologists
Radio Tracking Ethics
Underwater Geyser

Volume 1

Number 1



Welcome to Yellowstone Science

For more than a century, Yellowstone National Park has been recognized as a superb “outdoor laboratory” for many kinds of scientific research. The laboratory gets busier every year.

Last year, Yellowstone hosted 308 research projects involving 73 universities and foundations, 12 federal agencies, 7 state agencies and 3 corporations. These projects ranged clear across the scientific disciplines: 71 in physical sciences, 68 in forest, range, and plant ecology, 59 in assorted wildlife topics (with another 17 on wolves and 13 on bears), 39 in aquatic studies, 29 in microbiology (Yellowstone’s hot-water life forms are of world interest), and 12 more in assorted prehistoric, historical, sociological subjects.

With the launching of this periodical

we hope to accomplish at least two things. First, we will provide those widely scattered investigators with an opportunity to communicate with each other; at its best, *Yellowstone Science* will be a forum and a clearinghouse for them, to discuss issues and needs, and to exchange ideas.

Second, we can give the public a previously unavailable look at all this exciting science. We know that isn’t a simple goal. Some of this science involves the perennial hot topics that make so many headlines. Yellowstone’s Chief of Research refers to Yellowstone’s administration as “resource management in a goldfish bowl” because the public interest in the park is so intense. Yellowstone exists in an atmosphere of almost continuous controversy; wolves,

fire, bears, geothermal energy, elk, ecosystem processes and management, and a host of other topics cycle through the public’s attention on an almost predictable basis. But the research on those topics is only a small part the spectrum of science in Yellowstone.

Our primary goal is to explore the full breadth of the work being done in the park—to celebrate, through the eyes and ears and voices of the researchers themselves, the knowledge and wonder they so often find in this amazing place. At the same time, and with younger readers especially in mind, we’d like to show, through example, how science works: what its limitations and strengths are, and what it means to all of us who care about Yellowstone.

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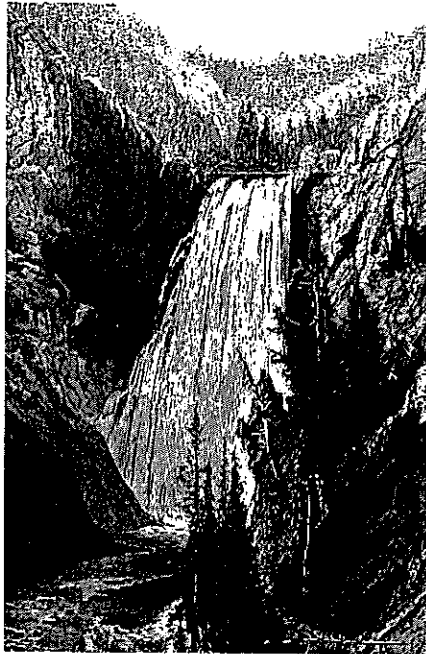
Yellowstone Science

A quarterly publication devoted to the natural and cultural sciences

Volume 1

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Fall 1992



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On the cover: A woodcut by Thomas Moran, based on his 1871 visit to the park area, showing the first known image of an identifiable Yellowstone fire. The view is east from West Thumb Geyser Basin, with smoke rising from Pumice Point. Fire history research indicates this area did burn around 1867, plus or minus 3 years. Moran may have seen the fire (though no reports of the expedition mention it), or may have noticed the recent burn site and added smoke for dramatic effect (from *the Aldine* 6[4]:74, April 1873).

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Yellowstone Science is published quarterly, and submissions are welcome from all investigators conducting formal research in the Yellowstone area. Editorial correspondence and requests for information about how to receive this publication should be sent to the Editor, *Yellowstone Science*, Division of Research, Post Office Box 168, Yellowstone National Park, WY 82190.

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Global Climate Change in the Greater Yellowstone Ecosystem

How will we fare in the Greenhouse Century?

by William H. Romme and Monica G. Turner

Global climate change, due to human-caused atmospheric disturbances, would have far-reaching effects on the Greater Yellowstone Ecosystem (GYE). Potential changes in temperature and precipitation are not well understood, but our knowledge of past climates in the GYE provides us with examples of the climate variations and how they might affect life here.

During the most recent glacial period, 20,000 to 16,000 years ago, the upper timberline in this part of the Rocky Mountains apparently was 2,000 to 3,900 ft. (600 to 1,200 m.) lower than today, and most of the Yellowstone Plateau was glaciated. As global temperatures increased and glaciers retreated (14,000 to 13,000 years ago in the GYE), the upper timberline shifted upward, and coniferous forests became established. The early Holocene (10,000 to 4,000 years ago) was a period of maximum warmth in the Yellowstone region, but the climate became somewhat cooler and possibly wetter in mid-Holocene, so that the lower timberline in the eastern GYE moved downward 5,400 to 4,400 years ago.

Because of increases in carbon dioxide and other greenhouse gases, another episode of global climate change is expected in the coming century. Current computer simulations of global climate change project an average rise in global temperature ranging from 34 to 40°F (1.5 to 4.5°C).

Projected Climate Scenarios

There is considerable uncertainty about effects of climate change on the

region. Rainfall may increase, decrease, or remain the same. In addition, increases in atmospheric carbon dioxide may have direct effects on vegetation. For example, the water-use efficiency of plants may increase along with increased carbon dioxide. Thus, the warmer temperatures and the rise in evapotranspiration (that is, the loss of water from the soil through evaporation and from plants through transpiration)

would increase plant water stress unless compensated for by increased precipitation or enhanced water-use efficiency.

We emphasize that these ecological changes are projections, not predictions. Our present understanding of the impending climate changes are still too rudimentary to permit confident predictions.

The Warm, Dry Scenario

Higher summer temperatures would increase the growing season at high elevations. The upper timberline would probably shift to a higher elevation, an increase of 1,500 to 3,800 ft. (460 to 1,150 m.). For the projections in this paper, we use a conservative estimate of 1,500 ft. (460 m.). Upper timberline in Greater Yellowstone is now at around 9,500 ft. (2,900 m.), and would move to around 11,000 ft. (3,360 m.). The alpine zone could disappear completely in Yellowstone National Park, where the highest point, Eagle Peak, is only 11,286 ft. (3,440 m.). In the highest peaks of the Absaroka, Teton, and Wind River Ranges, an alpine zone would persist. Alpine species vulnerable to these changes include the arctic gentian, alpine chaenactis, rosy finches, and water pipit.

The lower timberline would also shift upward 1,500 ft (460 m) or more, reducing the total forested area because there is less land at higher elevations. This would in turn reduce the amount of high-elevation forest types. For example, whitebark pine forests occur in a zone from 8,500 to 9,500 ft. (2,600 to 2,900 m.), which occupies an area of



The fairy slipper, dependent on old-growth forest habitats, could be seriously affected if the climate grows warmer and drier. Renee Evanoff illustration.

about 617,750 acres (250,000 hectares) within Yellowstone National Park. If vegetation zones shifted upward by 1,500 ft. (460 m.), then whitebark pine would be found from about 10,000 to 11,000 ft. (3,060 to 3,360 m.), with an area of only 66,700 acres (27,000 ha.). This is a 90 percent decrease in habitat for whitebark pine, an important food source for Clark's nutcrackers, red squirrels, and grizzly bears.

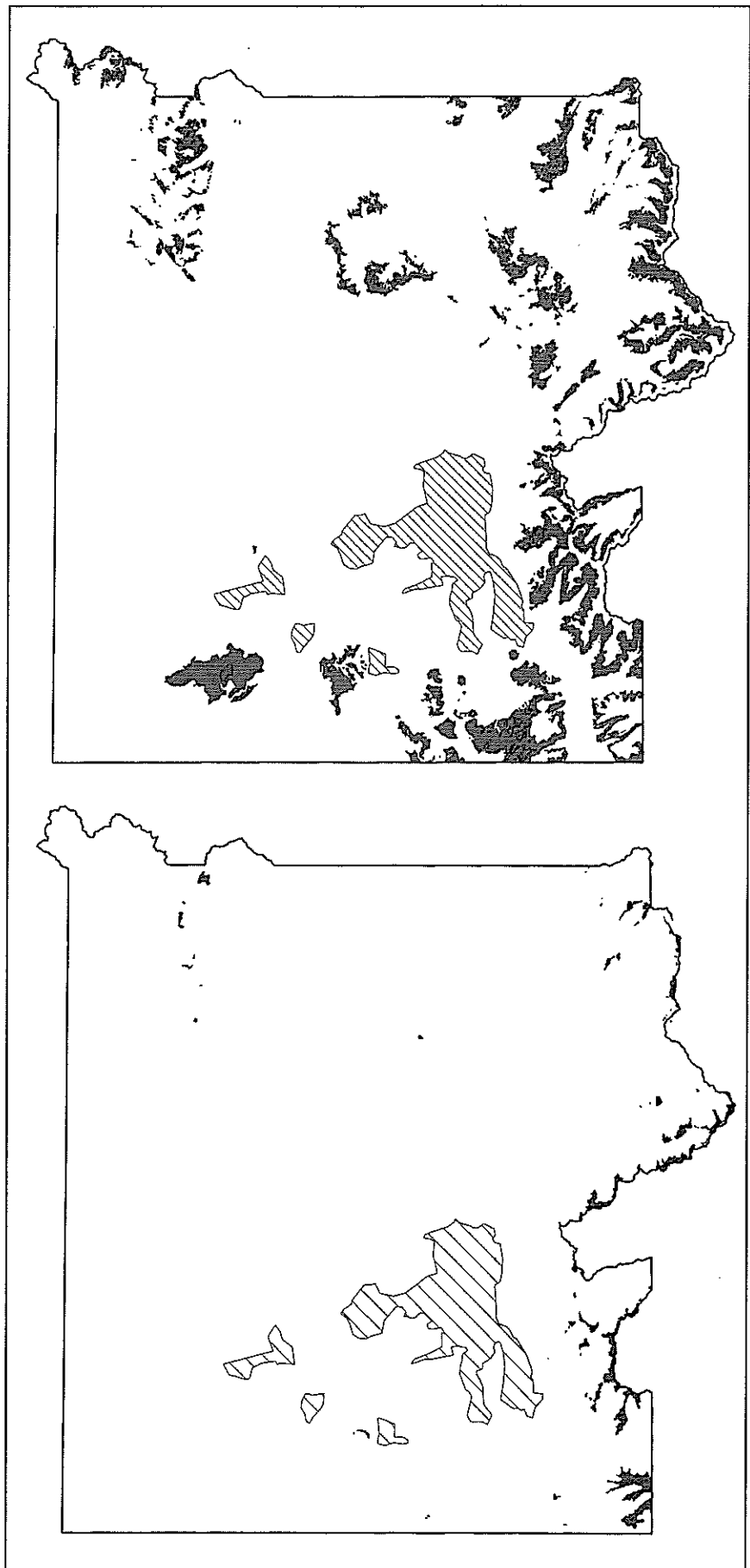
Douglas-fir, on the other hand, would be favored by the change. A 1,500-ft. (460 m.) upward shift would actually result in a larger potential range for this species in Yellowstone Park, because most of the park lies above 6,600 ft. (2,000 m.) and Douglas-fir occurs mostly between 6,200 and 7,200 ft. (1,900 and 2,200 m.). However, Douglas-fir would probably disappear from lower elevation areas elsewhere in Greater Yellowstone, so its regional abundance would remain the same or decrease.

The subalpine forest landscape of Greater Yellowstone contains numerous old-growth stands that exceed 200 years in age. If a warmer, drier climate leads to an increased frequency of severe stand-replacing fires, the landscape could be converted into one dominated by younger stands, as in the Canadian Rockies and subarctic. Habitat for old-growth species, including the northern twinflower, fairy slipper, pine marten, and goshawk, could become smaller in area and more fragmented.

With an upward shift in the lower timberline, the area of low-elevation nonforest vegetation would increase. Animals characteristic of treeless landscapes, such as pronghorn and badger, might become more numerous. Sagebrush-grasslands, dominated by big

Whither the whitebark?

The upper map shows current distribution of whitebark pine, a key food source for grizzly bears, in Yellowstone Park. The lower map shows remaining available habitat under the warm, dry scenario described on pages 4 and 5. Maps courtesy of the Yellowstone Geographic Information System Laboratory, Yellowstone Park.





sagebrush, bluebunch wheatgrass, and Idaho fescue, probably would move to higher elevations. At the lowest elevations, sagebrush-grasslands could be replaced by semidesert vegetation, characterized by saltbush and greasewood.

Species will respond individually to the environmental changes because of differing physiological tolerances, resulting in altered success between competing species. Entire life communities could undergo major changes.

The total numbers of elk, bison, and other native ungulates are limited primarily by the availability of winter forage. Nonforested areas at low elevations provide the major winter habitat for these animals. Milder winters and a larger nonforest area at low elevations could mean higher populations of ungulates throughout Greater Yellowstone. Of particular significance would be the increased winter habitat within protected parks, which lie at relatively high elevations. However, the associated drier conditions also might depress plant production, and elevated atmospheric carbon dioxide could produce altered carbon-nitrogen ratios in plant foliage, canceling out the

habitat enhancements of milder winter weather.

The Intermediate Scenario

In the intermediate scenario, a large, compensating increase in water use efficiency in plants would accompany increased temperature, increased evapotranspiration, and reduced or unchanged precipitation. Length of the growing season would increase, upper timberline would move upward, the alpine zone would be reduced, and local extinction of some alpine species could occur.

On the other hand, the position of the lower timberline might not shift, because the effects of higher evapotranspiration would be compensated for by increased water use efficiency. Thus, the elevational range of Douglas-fir could expand, because its lower limits, which might not change, are set by drought stress.

With a higher upper timberline and no change in lower timberline, the total forest area would increase. However, the forests would probably shift to younger age classes, because the increase in water use efficiency could

One of Yellowstone Park's foremost attractions is its large herds of ungulates. Elk populations, already controversial in park management dialogues, could increase under some future climate scenarios.

compensate for physiological drought stress, but would not reduce the occurrence of severe fires.

The area of nonforest communities at low elevations would not change in this scenario, but there could be dramatic changes in species composition, because plant species would not respond identically to the changes. The area of nonforested winter range also would not change in this scenario, but the range could be more accessible in milder winters. The fertilization effect of elevated carbon dioxide could increase forage production, but soil nutrient limitations and altered carbon-nitrogen ratios might limit this increase.

The Warm, Wet Scenario

In this, as in the previous scenarios, warmer temperatures probably would lead to an upward shift in upper timberline, and some alpine extinctions. The

range of whitebark pine would shift upward and occupy a smaller area. With increased precipitation, however, even the remaining subalpine environment could become unsuitable for this species because of increased competition with other species.

Whitebark pine is near the southern limit of its distribution in Greater Yellowstone. A climatic shift to wetter summers could result in further reduction or even local extinctions of whitebark pine in Greater Yellowstone. Drought stress at low elevations would be eased, and the lower timberline could shift to a lower elevation. The range of Douglas-fir could expand both upward and downward in this scenario, increasing forest area. Wetter conditions, especially in summer, could lead to a decrease in fire frequency and severity and a shift in forest age-class distribution to older age classes. Thus old-growth habitat would increase.

The nonforest area at low elevations would be reduced if the lower treeline moved downslope. Semi-desert species and communities could disappear entirely from YNP. Less nonforested area means less winter range and fewer ungulates. Ungulates are adaptable, however, and would probably use forest habitats more, and milder winter temperatures increases in forage production might increase ungulate carrying capacity.

Warmer temperatures, longer growing seasons, increased precipitation, and elevated carbon dioxide could increase primary vegetation productivity, but other limiting factors, such as soil nutrients, might prevent or limit such increases. Because individual plant species will each respond differently to all of the changes, some dramatic changes in community composition could occur throughout the vegetation of the GYE.

How Will It Happen?

The three climate scenarios share some similarities. The upper treeline in the GYE is likely to move toward higher elevations in response to increased temperatures, and the distribution of Douglas-fir is likely to expand. The alpine and whitebark pine zones would

probably decrease in extent and become more fragmented, causing some alpine species and communities to become locally extinct within YNP and possibly the GYE during the next few centuries. However, the total number of species within YNP and the GYE actually may change little. Semi-desert vegetation, which is currently rare and restricted to specialized habitats, may expand in lower-elevation portions of the GYE, especially under the warm, dry scenario.

The simplistic prospect of a smooth northerly and upward migration of plant species and communities is complicated by individual species responses and by the rate at which climate change may occur. By the time a slow-growing tree reaches reproductive age, the environment may no longer be suitable for seedling survival. Probably the species that will most quickly track the moving thermal zones are those with short, rapid life histories, e.g., introduced weeds, or species with a broad distribution such as lodgepole pine. The species that will respond least effectively are the long-lived species that reproduce late or irregularly and those with already limited, fragmented distributions, such as whitebark pine and alpine species. Competitive interactions between species also would be complicated as new species from lower elevational zones become established in the higher zones where adults of the formerly dominant species still exist.

Mature individuals of many long-lived species may persist in their present locations for as much as decades, even centuries, after the climate becomes unsuitable for survival of their offspring. Plant communities might appear stable for a long time, but after a disturbance (such as fire, insect outbreak, or wind-storm) the mature forest community could be replaced by a completely different suite of species.

Research and Monitoring Needs

It is important to design long-term measurements creatively so that they are sensitive to early indications of ecological change. For example, species or individuals that are near the limits of their range of tolerance are

likely to respond more rapidly than those that are well within their physiological range. Upper and lower timberlines can respond quickly even to climate changes of the magnitude observed in the last 100 to 500 years, and should be high priority sites for research and monitoring.

Another early indicator of global climate change may be alterations in the frequency and severity of natural disturbances. Given the importance of fire in the GYE, particular emphasis should continue to be placed on increasing our ability to predict the occurrence and effects of fire. Post-fire succession should be monitored following the 1988 fires and after future fires, especially in areas near upper and lower timberline.

The grasses and shrubs are likely to show more rapid changes in productivity and composition in response to climate than the subalpine forests. The grasslands also are influenced by native ungulates, so research into vegetation-climate-herbivore interactions should continue.

Although the inevitability of global climate change is not assured, the potential implications are of sufficient magnitude that it would be foolish to ignore them. The conservation of biological diversity in extensive natural areas such as the Greater Yellowstone Ecosystem will become increasingly difficult as the broad-scale constraints on the biota undergo changes that are more rapid than those experienced in the past. Explorations of potential scenarios can provide useful tools to increase our understanding of the ecological dynamics of climate change, and can stimulate discussion about the strategies appropriate for maintaining biological diversity in the face of environmental change.

William Romme, of Fort Lewis College, Durango, Colorado, and Monica Turner, of the Environmental Sciences Division, Oak Ridge National Laboratory, Tennessee, are both active in ecosystem-scale studies in Greater Yellowstone. This article is an abridged version of a longer paper that appeared in Conservation Biology in September, 1991.



Bugged Bears & Collared Cougars

The rewards and challenges of wildlife radiotelemetry

by Mark Johnson

As the sun sets beyond the meadow, a man in Bermuda shorts, with camera in hand, watches a pronghorn move slowly toward him. As if unaware of its admirer, the pronghorn continues to graze, briefly stepping onto a tall mound. The scene appears perfect, with sunset colors, a mountainous background, and a wonderful pose by the graceful animal. But then the late-afternoon sun highlights something else, something less natural: the trim, artificial circle of a radio collar riding low on the pronghorn's neck. The photographer no longer has the scenic picture he was hoping for.

For decades, marked, tagged, and collared animals have been a part of the Yellowstone Park setting, and for just as long, people have discussed and debated the effects of these scientific attachments on animals and on our appre-

ciation of those animals. For some people, tags, collars, and other gear show positive efforts to understand and manage the animals. Others wonder if these manipulations are necessary, humane, or even appropriate in a national park.

Today, with growing concerns over humane treatment of animals, and rapidly changing public attitudes about the aesthetic and even spiritual place of wild animals in human society, a marked animal generates questions that address the changing views towards wildlife, the accuracies of our science, and the goals of our national parks.

What is radiotelemetry?

Radiotelemetry--attaching a transmitter to an animal to study it remotely--is an important technique for gathering

information from long distances. Usually such studies focus on the animal's location, but telemetry can also determine the animal's temperature, heart rate, body position (to determine if it is feeding or resting), and even if the animal is still alive. A telemetry unit consists of a transmitter, battery, antenna, and some form of harness or other attachment to the animal. The package is designed to conform to the shape and behavior of the animal. Each animal in the study has its own signal frequency, so any one of them can be identified by a biologist with a receiver.

Originally, telemetry units were bulky and heavy, and were placed only on large animals, such as elk or bears. Early researchers were extremely resourceful, building "home-made" collars strong enough to endure the elements (including the attentions of ani-

Interagency Grizzly Bear Study Team member attaching radio collar to an adult grizzly bear.

mals, as in the case of a collared sow whose cubs might take to chewing on the collar). In Yellowstone, for example, some grizzly bear collars used during the pioneering Craighead research project (1959-1970) were made of metal strapping covered with garden hose, and the transmitter unit was encased in fiberglass with liberal windings of electrical tape. Later, heavy molded plastic encased the telemetry units, and a strong fabric strap held the unit in place.

Today, advanced technology has significantly improved telemetry with miniaturized electronic components. Biologists now radio track animals as small as bats, toads, and fish (the signal even works in water). Small telemetry units attach to animals with collars, legbands, and backpacks, and sterile transmitters are surgically implanted in the abdominal cavities of several species.

Some animals, because of their shape or extreme range, present unusual challenges. In 1984, greater sandhill cranes

summering in Yellowstone National Park were studied using telemetry attached by legbands. Solar panels in the telemetry unit provided power for as long as 4 years. Small rivets attaching transmitter units to legbands usually corroded after the unit quit functioning, so the transmitter would fall off. With these advanced telemetry units, biologists learned that cranes summering in Yellowstone National Park migrated through the San Luis Valley, Colorado in spring and fall and wintered in the Rio Grande Valley in New Mexico.

Amphibians and reptiles are especially difficult to find and study, though worldwide concern over declining amphibian populations makes such studies extremely important. A herpetologist recently described the classic capture-recapture technique used with snakes as the "mark, release, and never see them again" technique. Biologists at Idaho State University plan to study spotted frogs and western toads--two Greater Yellowstone species experiencing declines in other areas. They will place "backpacks" with 1.9-gram transmitter units onto 40-gram animals (about 3 inches in body length). At this writing, prototype backpack units are being de-

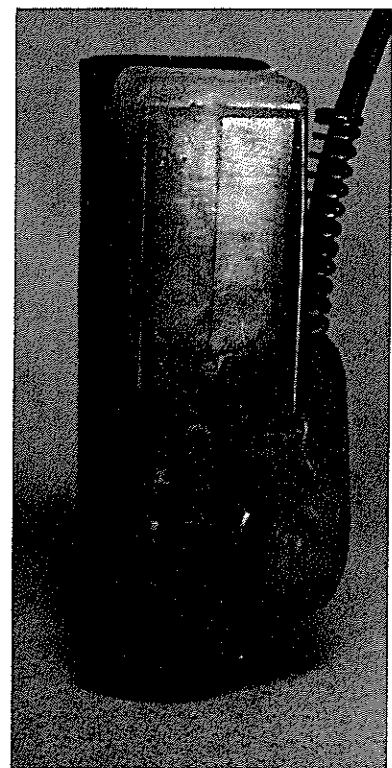
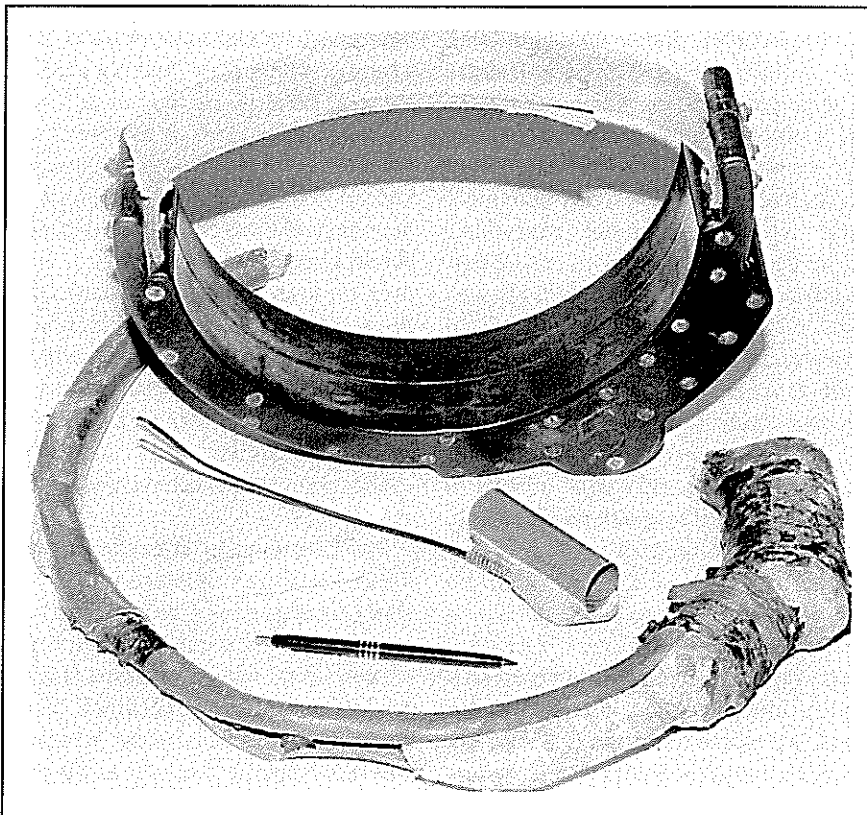
veloped under controlled conditions to ensure there is limited impact on the animal.

When is telemetry justified?

The reasons for telemetry are surprisingly diverse. There are practical management reasons, such as the need for collecting data on bears to assist with management of human/bear conflicts. Most people would agree that human

Below left: a collection of wildlife radiotransmitters, including (in front) a grizzly bear collar used during the 1960s in Yellowstone (garden hose over metal strapping, with the transmitter encased in fiberglass) a slightly less vintage bear collar with canvas strap attached to a transmitter encased in heavy plastic, a legband transmitter for sandhill cranes (attached to the upper leg, so the antenna will extend downward parallel to the leg), and a abdominal radiotelemetry implant for 8-week-old coyote pups.

Below: a closer view of the legband transmitter. The solar panels (visible on the top half of the unit) replace batteries as a power source.



safety is a very high priority of park managers, and active monitoring of seasonal bear movements can alert managers to the movements of the animals into possible conflict situations.

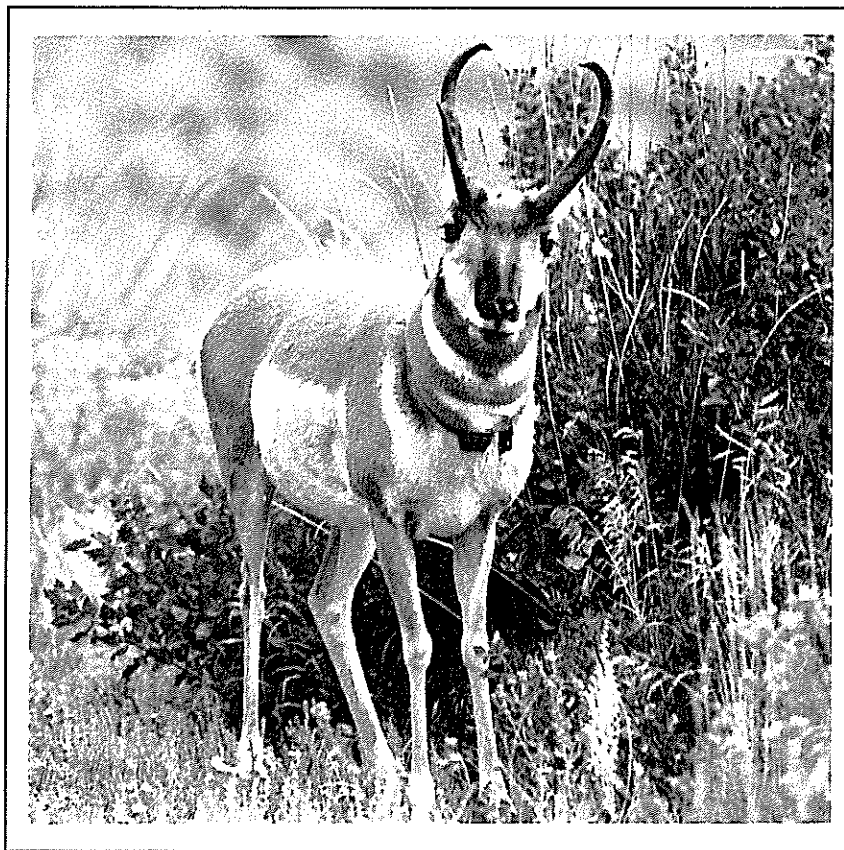
Political and legal reasons can also dictate the need for telemetry studies, as when political processes for wilderness designation depend heavily on scientific information about endangered and threatened species. Federal agencies are required by law to determine the condition of endangered wildlife populations, and such information can often only be obtained through radiotelemetry. In Yellowstone, the possibility of reintroduction of wolves required managers to learn the condition of many other species in order to project potential influences of wolves, both on other predators and on potential prey. These legal imperatives can leave managers with little choice but to employ radiotelemetry.

In most cases, though, the use of radiotelemetry comes down to striking a balance between the impacts on the animals and the value of the information that is gathered. Stu Coleman, Resource Management Specialist, Yellowstone National Park, says that "if information gained is worth more than the disturbance to the individual and species studied, then the telemetry study is worth doing."

Yellowstone's famous grizzly bears are a good example of this. Radiotelemetry has been used for more than 30 years to monitor population trends, movement patterns, food habits, and habitat use. During 1990, the IGBST monitored a total of 35 grizzly bears for ecological studies. Telemetry studies with these 35 bears have played a major role in the preservation of this threatened species and their habitat. And as research continues, new pressures on the bears and their habitat expand the need to learn more.

Does telemetry affect the animal?

When telemetry *is* justified and animals *are* handled and marked, it is important, both ethically and scientifically, to affect the animal as little as possible. Few biologists would deny that telem-



etry affects the animals they are studying, but they must always ask how these effects can be determined and minimized.

Kerry Murphy of the Wildlife Research Institute studies mountain lions in Yellowstone's Northern Range. Unlike most studies, which collar only to a portion of the population, Kerry strives to radio collar all mountain lions in his study area. He describes an ethical scientist as "one who does everything from the very beginning to ensure that study techniques do not affect the animal. This is in theory, though. In reality, effects will likely occur, so when effects are seen, a good researcher will change study methods."

Kerry recognizes that studying lions might influence individual animals in several ways: 1) capture and handling, 2) wearing of the radio collar, and 3) disturbing the animal while radio tracking. Kerry's research statistics--72 radio collared lions over 152 captures with no capture-related mortalities--is not achieved without a conscientious and introspective attitude. From observing animal behavior during capture to monitoring of the captured animal's

vital signs, every attention is paid to its condition until it is safely released again.

Determining the impact of telemetry on the animal after it is released is extremely difficult. Biologists commonly assume that some impacts, such as any resulting from wearing a collar, are negligible if the animal performs basic activities such as establishing a territory, mating, and producing young. Such rationale is weak, because these may be crude measures ignoring more subtle impacts. In many cases, however, these are the only criteria that can be used, because it is impossible to know if the animal is really behaving as it would if it didn't have the collar on. Uncollared animals cannot be followed as well as collared ones, and so we cannot compare the behavior of the two groups.

Tracking may also affect the animals. Telemetry allows biologists to approach study animals at will, so personnel can potentially stress the animal, and change its normal movement patterns and behavior, reducing the accuracy of the study. As part of his study, Kerry has followed specific lions for as much as 55 consecutive days to determine the



A spotted frog wearing a prototype .07 ounces (2 grams) backpack radiotransmitter. This frog weighs only .9 oz. (26 g.), and is just "modelling" the transmitter for photographic purposes; frogs that will wear this unit in field research situations will more typically weigh 1.4 oz. (40 g.). The transmitter has a range of about 325 yards (300 m.). The backpack is made from panty hose fabric. Photo courtesy of Charles Peterson, Curator of Herpetology, Idaho Museum of Natural History.

lion's frequency of predation. To reduce his effects on the lions, he uses the telemetry to avoid disturbing the animal. Because Kerry and his team usually know the location of the lion, they are able to wait until they are sure that it has left the area. For example, lion kills are not investigated until the lion has completely left the area of the carcass.

One way to reduce the long-term effects of collaring animals is the use of "break-away" collars that deteriorate and fall off after a certain period of use. In a study where it is difficult to recapture the animal, such a collar reduces the impacts of research.

Is telemetry humane?

The public's increased concern for animal welfare has increased the self-awareness of wildlife personnel and agencies. More than ever, wildlife biologists are addressing the animal's well-being as the highest priority of telemetry programs. Dr. Robert Crabtree, of Montana State University, currently oversees coyote studies in the Lamar Valley and the Blacktail Plateau in Yellowstone National Park. Yellowstone coyotes are one of the few relatively undisturbed and unexploited populations in temperate North America. In his study, Dr. Crabtree uses telemetry to study the movements, behavior, and mortality causes of coyote pups. Little is known about these young animals, partly because they grow too fast to be radio collared.

To help overcome this obstacle, I recently assisted Bob in his research

by surgically implanting small, sterile transmitters into the abdominal cavities of coyote pups. The coyote biologists recognized we were affecting pups through capture, handling, and surgery, so we all took every precaution to minimize physical and psychological stresses. All field personnel spoke in soft whispers. Pups stayed in cool, dark cloth bags, and were handled as little as possible. Once under anesthesia, temperature, pulse, and respirations were monitored every 10-15 minutes.

Surgeries were conducted on the site of the capture, in a tent much like a small field clinic. And as soon as the pups recovered, they were quickly returned to their quiet den. After each session, we reviewed the day's events, seeking ways to refine and improve our work.

While those of us in wildlife science and management are constantly improving the capabilities of radiotelemetry and reducing the impact on wildlife, the *real* ultimate goal may be never to handle wildlife at all. But handling wildlife cannot yet be avoided, and so when telemetry is needed, the highest priority should be the well-being of the animal.

What do park visitors think of it all?

During a study of white-tailed deer in Cades Cove of Great Smokies Mountain National Park, visitors were surveyed to determine their attitudes towards radio collared deer. The survey revealed that park employees were more bothered by the adornments on the animals than was the general public. In fact, given time educating the general

public, the public was very supportive.

Still, the goals and policies of the National Park Service are to keep animals in as natural a state as possible. The University of Wisconsin-Madison is currently conducting research to provide alternatives to visible radio collars. Bob Garrett and P. J. White are studying the highly visible elk in the Firehole/Madison area of western Yellowstone. Their principle objectives are to investigate links between habitat, diet, physiology, and population dynamics. Bob and P.J. are testing abdominal implants in 6 of 25 radio collared elk to see if implants can be a reliable and less visibly distracting alternative to collars.

It is remarkable how technology has allowed us to follow and study animals from a distance, and to locate them whenever we wish. The diversity of telemetry has almost matched the diversity of wild animals in the Greater Yellowstone Area. Although technology will continue providing us with new techniques and approaches for studying wildlife, there must always be an underlying concern about what we are doing and why we are doing it. Radio tracking of wildlife can never be taken lightly, no matter how far technology advances. It is important for researchers and lay persons alike to ensure that we are conscious of our reasons, conscientious in our actions, and, most of all, respectful of the wild animals that mean so much to us.

Mark Johnson is a wildlife veterinarian with a wide experience at wildlife handling and radiotelemetry. He currently works for the Research Division in Yellowstone Park.